MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 1, 2016/2017**

## EEE1016 – ELECTRONICS 1

(All Sections / Groups)

19 OCTOBER 2016
2:30 pm – 4:30 pm
(2 Hours)

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**INSTRUCTION TO STUDENTS**

1. This Question paper consists of **6 pages** including cover page with **4 Questions** only.

2. Attempt **ALL** the questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the answer Booklet provided.

## QUESTION 1

(a) Table Q1(a) presents a list of elements and their atomic numbers. Identify **TWO** elements which can be used to form an N-type semiconductor material. State their electron configurations and justify your answer. [4 marks]

| Element | Atomic number, $Z$ | Electron configuration |
|---|---|---|
| A | 5 | $1s^2\ 2s^2\ 2p^1$ |
| B | 15 | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ |
| C | 32 | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^2$ |
| D | 49 | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 5s^2\ 5p^1$ |

**Table Q1(a)**

(b) For a sample of intrinsic Gallium Arsenide (GaAs), the electron and hole mobilities are $\mu_n = 8500\ cm^2/V\text{-}s$ and $\mu_p = 400\ cm^2/V\text{-}s$, respectively. At T =300°K, a drift current density of 75 $A/cm^2$ is established in the pure GaAs with an applied electric field of $E = 15\ V/cm$. The GaAs material is doped to the extent of $2 \times 10^{16}$ donor atoms/$cm^3$ and $5 \times 10^{15}$ acceptor atoms/$cm^3$.

(i) Find the intrinsic carrier concentration of the GaAs. [3 marks]

(ii) Determine the electron and hole concentrations of the extrinsic GaAs material. [6 marks]

(iii) Calculate the drift current density of the extrinsic GaAs for $E = 12\ V/cm$. [3 marks]

(c) A piecewise linear model is considered for the diode circuit as depicted in Figure Q1(c). The diode has a cut-in voltage $V_\gamma = 0.7$ V and a forward diode resistance $R_f = 10\ \Omega$. Find the current $I$ and the voltage $V_o$ in the circuit. [4 marks]

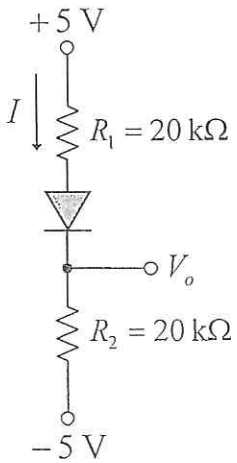


**Figure Q1(c)**

**Continued ...**

(d) An ideal Zener diode is used in the design of a voltage regulator circuit as shown in Figure Q1(d), in order to maintain an output voltage of 12 V for a load current variation between 0 mA and 250 mA. Find the value of resistor $R_S$. [5 marks]

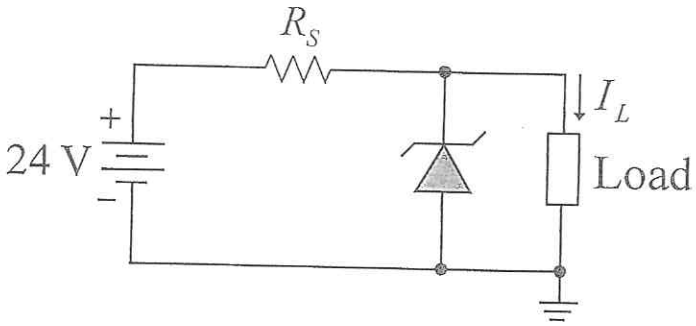


Figure Q1(d)

## QUESTION 2

The rectifier circuits shown in Figure Q2(a) and Figure Q2(b) produce a single-polarity output by converting negative alternations to positive alternations.

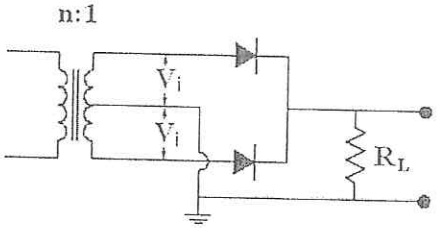


Figure Q2(a)

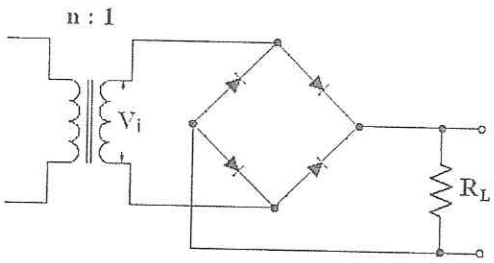


Figure Q2(b)

(a) (i) Name the rectifier circuits of Figure Q2 (a) and Figure Q2 (b). [2 marks]

(ii) Give three disadvantages of the rectifier in Figure Q2(b) as compared to the rectifier in Figure Q2(a). [3 marks]

(b) The input voltage waveform $V_i$ is shown in Figure Q2 (c) below. Draw the output voltage waveforms of these two rectifiers. Assume all diodes in the circuits have cut-in voltage, $V_\gamma = 0.7$ V, and $R_f$ is negligible. [4 + 4 marks]

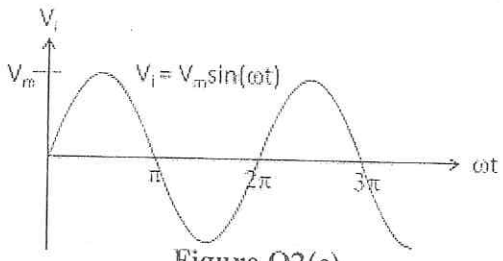


Figure Q2(c)

Continued ...

(c) The input voltage signal for the rectifier of Figure Q2(b) is $V_i = V_m \sin(2\pi ft)$ with $V_m = 12$ V and $f = 60$ Hz. Given that the load resistor $R_L = 5\text{k}\Omega$. Determine:

(i) The average output voltage, $V_{o(av)}$ [2 marks]

(ii) The average load current, $I_{o(av)}$ [2 marks]

(iii) The rms load voltage, $V_{o(rms)}$ [2 marks]

(iv) The rms load current, $I_{o(rms)}$ [2 marks]

(v) The ripple factor, $\gamma$ [2 marks]

(vi) The output frequency, $f$ [2 marks]

## QUESTION 3

(a) Figure Q3(a) shows a simple BJT amplifier circuit. Given that the DC amplification factor, $\beta = 200$ and $V_{BE} = 0.7$ V. Calculate the following parameters:

(i) The base current, $I_B$. [3 marks]

(ii) The collector current, $I_C$. [2 marks]

(iii) The base voltage, $V_B$. [1 mark]

(iv) The Collector-Emitter voltage, $V_{CE}$. [3 marks]

(v) The power dissipated by the BJT transistor [3 marks]

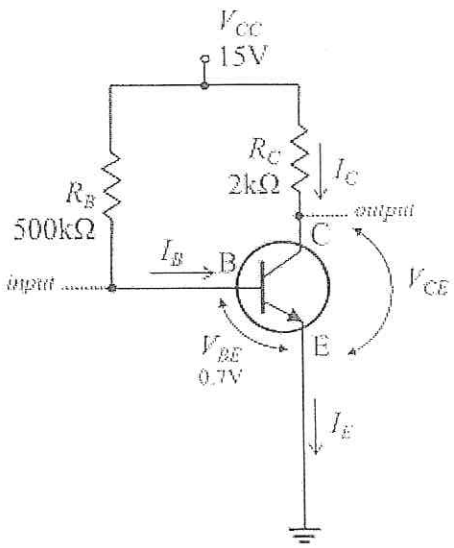


Figure Q3(a)

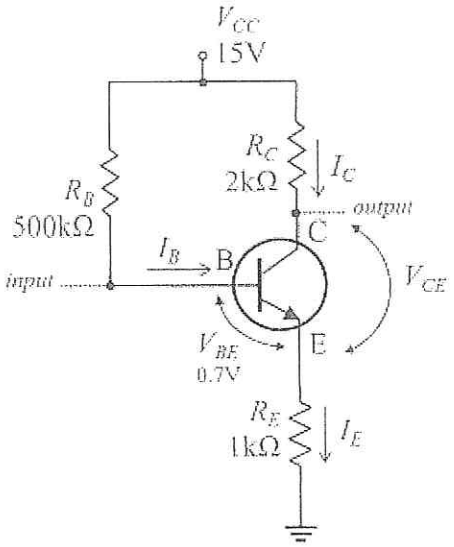


Figure Q3(b)

Continued ...

(b) An emitter resistor, $R_E$, is added to the BJT circuit of Figure Q3(a) and the new circuit is shown in Figure Q3(b). Compute the followings:

(i) The base current, $I_B$, of Figure Q3(b). [4 marks]

(ii) The collector current, $I_C$. [2 marks]

(iii) The emitter current, $I_E$. [2 marks]

(iv) The Collector-Emitter voltage, $V_{CE}$. [3 marks]

(v) The power dissipated by the BJT transistor [2 marks]

## QUESTION 4

(a) Figure Q4(a) shows an unloaded two-port circuit that represents an active device. When a signal generator, with a source voltage $V_S$ = 5mV and a source resistance $R_S$ = 500Ω, was connected to the input port, the voltage $V_I$ was measured to be 3.75mV. Calculate the internal impedance $Z_{in}$ of the two-port circuit. [4 marks]

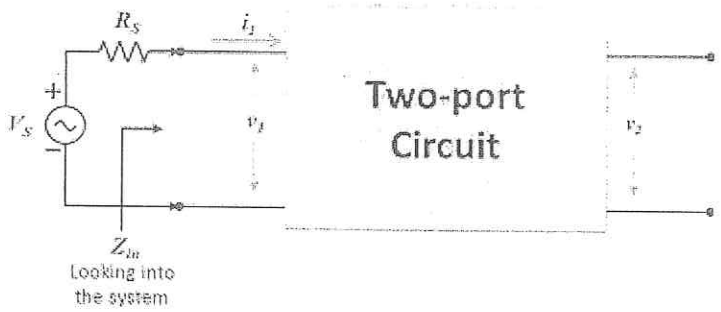


**Figure Q4(a): A Two-Port Circuit**

(b) Figure Q4(b) is a single stage BJT amplifier circuit. Draw the small signal equivalent circuit of the amplifier by showing all external and parametric components of the transistor, using the following transistor models:

(i) The $r_e$ model. [3 marks]

(ii) The $r_\pi$ model. [3 marks]

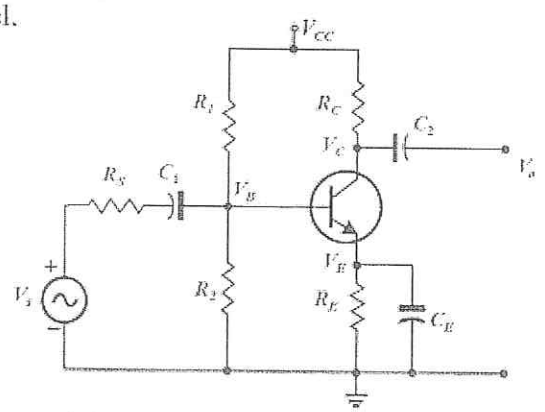


**Figure Q4(b): A Single Stage BJT Amplifier**

**Continued ...**

(c) Figure Q4(c) is a BJT transistor amplifier circuit with the following *h*-parametric values:

Input impedance, $h_i = 1200\Omega$,

Reverse voltage ratio, $h_r = 2.5 \times 10^{-4}$,

Forward current gain, $h_f = 150$, and

Output conductance, $h_o = 0\ \mu A/V$.

(i) Using the hybrid-h model for transistor, construct the small-signal equivalent circuit of the amplifier shown in Figure Q4(c). Show clearly all external components and the parametric values of BJT. [4 marks]

(ii) Derive the expression and calculate the current gain, $A_I = {}^{i_c}/_{i_b}$ [2 marks]

(iii) Derive the expression of the source current, $i_s$, in terms of the base current $i_b$, the resistance $R_1$ and $R_2$, and the *h*-parameters of the BJT. [3 marks]

(iv) From Question 4(c)(iii) above, derive and calculate the effective current gain, $A_{IS} = \dfrac{i_c}{i_s}$. [6 marks]

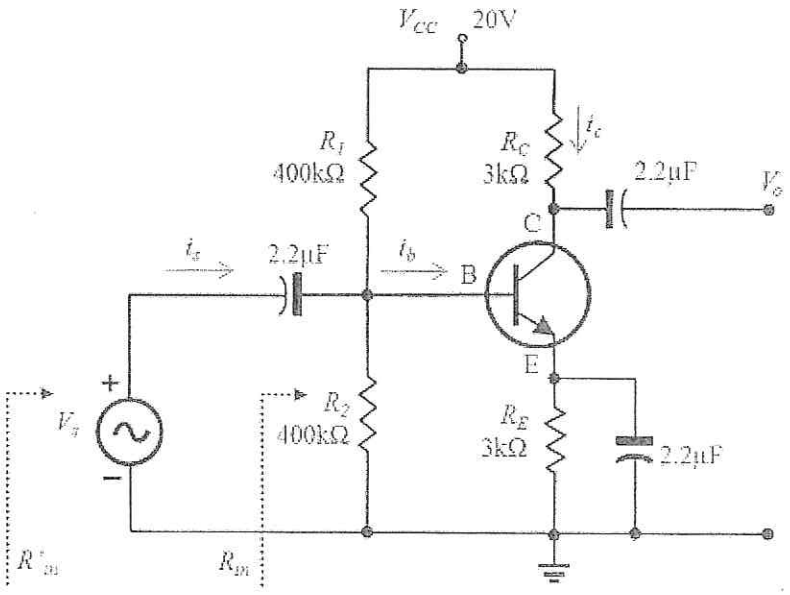


**Figure Q4(c)**

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